1992 HOUSATONIC RIVER TRIBUTARY BIOMONITORING SURVEY

Assessing Instream Impacts To Biota From Surface Water Supply Withdrawals

Commonwealth of Massachusetts
Executive Office of Environmental Affairs
Department of Environmental Protection
Water Pollution Control Technical Services

NOTICE OF AVAILABILITY

LIMITED COPIES OF THIS REPORT ARE AVAILABLE AT NO COST BY WRITTEN REQUEST TO:

MASSACHUSETTS DEPARTMENT OF ENVIRONMENTAL PROTECTION
DIVISION OF WATER POLLUTION CONTROL
TECHNICAL SERVICES SECTION
P.O. BOX 116
40 INSTITUTE ROAD
NORTH GRAFTON, MA 01536

Furthermore, at the time of first printing, eight (8) copies of each report published by this office are submitted to the State Library at the State House in Boston; these copies are subsequently distributed as follows:

- On shelf; retained at the State Library (two copies);
- microfilmed; retained at the State Library
- delivered to the Boston Public Library at Copley Square;
- delivered to the Worcester Public Library;
- delivered to the Springfield Public Library;
- delivered to the University Library at UMASS, Amherst;
- delivered to the Library of Congress in Washington, D.C.

Moreover, this wide circulation is augmented by inter-library loans from the above-listed libraries. For example, a resident of Winchendon can apply at the local library for loan of the Worcester Public Library's copy of any DWPC/TSS report.

A complete list of reports published since 1963 is updated annually and printed in July. This report, entitled "Publications of the Technical Services Section, 1963-(current year)," is also available by writing to the TSS office in North Grafton.

1992 HOUSATONIC RIVER TRIBUTARY BIOMONITORING SURVEY -

Assessing Instream Impacts To Biota From Surface Water Supply Withdrawals.

Laurie E. Kennedy
Environmental Analyst

Robert J. Maietta
Environmental Analyst

and

Robert M. Nuzzo
Aquatic Ecologist

Resource Assessment Project Number 92-5

MASSACHUSETTS DEPARTMENT OF ENVIRONMENTAL PROTECTION
DIVISION OF WATER POLLUTION CONTROL
TECHNICAL SERVICES SECTION
NORTH GRAFTON, MASSACHUSETTS

March 1993

Publication No. 17331 - 56 - 50- 1.21 - 4/93 - C.R.
Approved by: Philmore Anderson III, State Purchasing Agent

TITLE: 1992 Housatonic River Tributary Biomonitoring Survey - Assessing Instream Impacts To Biota From Surface Water Supply Withdrawals.

DATE: March 1993

AUTHORS: Laurie E. Kennedy, Robert J. Maietta, and Robert M. Nuzzo

REVIEWED BY:

Arthur S. Johnson
Technical Services Section
Resource Assessment Program Manager

APPROVED BY:

Alan N. Cooperman
Technical Services Section
Supervisor

COMMONWEALTH OF MASSACHUSETTS

EXECUTIVE OFFICE OF ENVIRONMENTAL AFFAIRS
Trudy Coxe, Secretary

DEPARTMENT OF ENVIRONMENTAL PROTECTION
Daniel S. Greenbaum, Commissioner

BUREAU OF RESOURCE PROTECTION
Arleen O'Donnell, Assistant Commissioner

DIVISION OF WATER POLLUTION CONTROL
Brian M. Donahoe, Director

FOREWORD

The Massachusetts Division of Water Pollution Control was established by the Massachusetts Clean Water Act, Chapter 21 of the General Laws as amended by Chapter 685 of the Acts of 1966. Included in the duties and responsibilities of the Division is the periodic examination of the water quality of various coastal waters, rivers, streams, and ponds of the Commonwealth, as stated in Section 27, Paragraph 5 of the Acts. This section further directs the Division to publish the results of such examination, together with the standards of water quality established for the various waters. The Technical Services Section of the Division of Water Pollution Control, located in North Grafton, MA (formerly Technical Services Branch, located in Westborough, MA), has among its responsibilities, the execution of this directive. This report is published under the Authority of the Acts, and is among a continuing series of reports issued by the Division presenting water quality data and analyses, water quality management plans, baseline and intensive limnological studies and special studies.

DISCLAIMER

Reference to trade names, commercial products, manufacturers, or distributors in this report constitutes neither endorsement nor recommendation by the Massachusetts Division of Water Pollution Control for use.

TABLE OF CONTENTS

LIST OF TABLES AND FIGURES

INTRODUCTION

Direct surface-water withdrawals from Massachusetts rivers, streams, and groundwater are utilized for public water supply, industrial, agricultural and other purposes. The Massachusetts Department of Environmental Protection's (DEP) Division of Water Supply (DWS) regulates water withdrawals in excess of an average of 100,00 gallons per day (GPD) pursuant to the Water Management Act, M.G.L.c.21G, and accompanying regulations 310 CMR 36.00. The Water Management Act (WMA) requires that permits be obtained for water withdrawers who did not register their 1981-1985 withdrawals, are new or are adding a new source, or who are exceeding or expect to exceed their registered withdrawal by 100,000 GPD. In order to assess the existing or potential impacts on instream biota, the Division of Water Pollution Control's Technical Services Section (DWPC's TSS) conducted biological and physicochemical monitoring in the vicinity of surface water withdrawals in the Housatonic River Basin which are expected by DWS to be in need of withdrawal permits. This survey was a pilot study aimed at integrating efforts of DWS and DWPC toward comprehensive (water quality and quantity) basin planning and permitting to ensure the protection of the designated uses of the streams as well as the protection of aquatic life (MA DEP 1990). Stream discharge measurements and physicochemical water quality sampling, in conjunction with Rapid Bioassessment Protocols (RBP) II and V (Plafkin et. al. 1989) were employed to assess the ecological integrity of the surface waters in the vicinity of water supply withdrawal sites. The survey also provided the opportunity to evaluate the biological condition of previously unassessed waters in terms of non-point source pollution impacts for the next 305(b) report.

Study Sites

Seven surface-water withdrawal sites in the Housatonic Basin are expected by DWS staff to be in need of Water Management Act permits. Four of the withdrawal sites supply water to the Dalton Fire District. These withdrawals are from Anthony Pond, Egypt Reservoir, Windsor Reservoir and Cleveland Reservoir. The Anthony Pond and Egypt Reservoir withdrawals currently have backup status for fire control. Belmont Reservoir in Hinsdale supplies the Hinsdale DPW. The Housatonic Water Works withdraws its water from Long Pond in Great Barrington. Lastly, the South Egremont Water Company withdraws its supply directly from Karner Brook.

Sampling station locations for each water withdrawal site (Figure 1) were selected at the time of field reconnaissance on 7 July 1992. Station locations were chosen to provide either an upstream reference or regional reference station, as well as a downstream test station. Six water withdrawal sites were evaluated with 11 sampling stations. The Long Pond withdrawal was not 'evaluated' in the same manner as the other withdrawal sites since the outlet stream was dry.

Water from Anthony Pond and Egypt Reservoir is piped underground to Little Egypt Reservoir where it is filtered. Egypt Reservoir receives flow from an unnamed perennial stream which originates on the North Mountain in Dalton. The outlet of the reservoir (unnamed but hereafter referred to as Egypt Brook), flows through a steep wooded area, passes under Holiday Road, and soon empties into Wahconah Falls Brook. Overflow from the Little Egypt Reservoir filtering plant also contributes to Egypt Brook upstream from Holiday Road. Anthony Pond appears to be a spring-fed pond located on North Mountain in Dalton. The outlet of the pond, Anthony Brook, is a first-order stream (Strahler nomenclature) which is joined by an unnamed, first-order perennial stream. Anthony Brook then continues to flow in a southerly direction down into Dalton, and passes through two small impoundments prior to flowing into Center Pond on the East Branch Housatonic River.

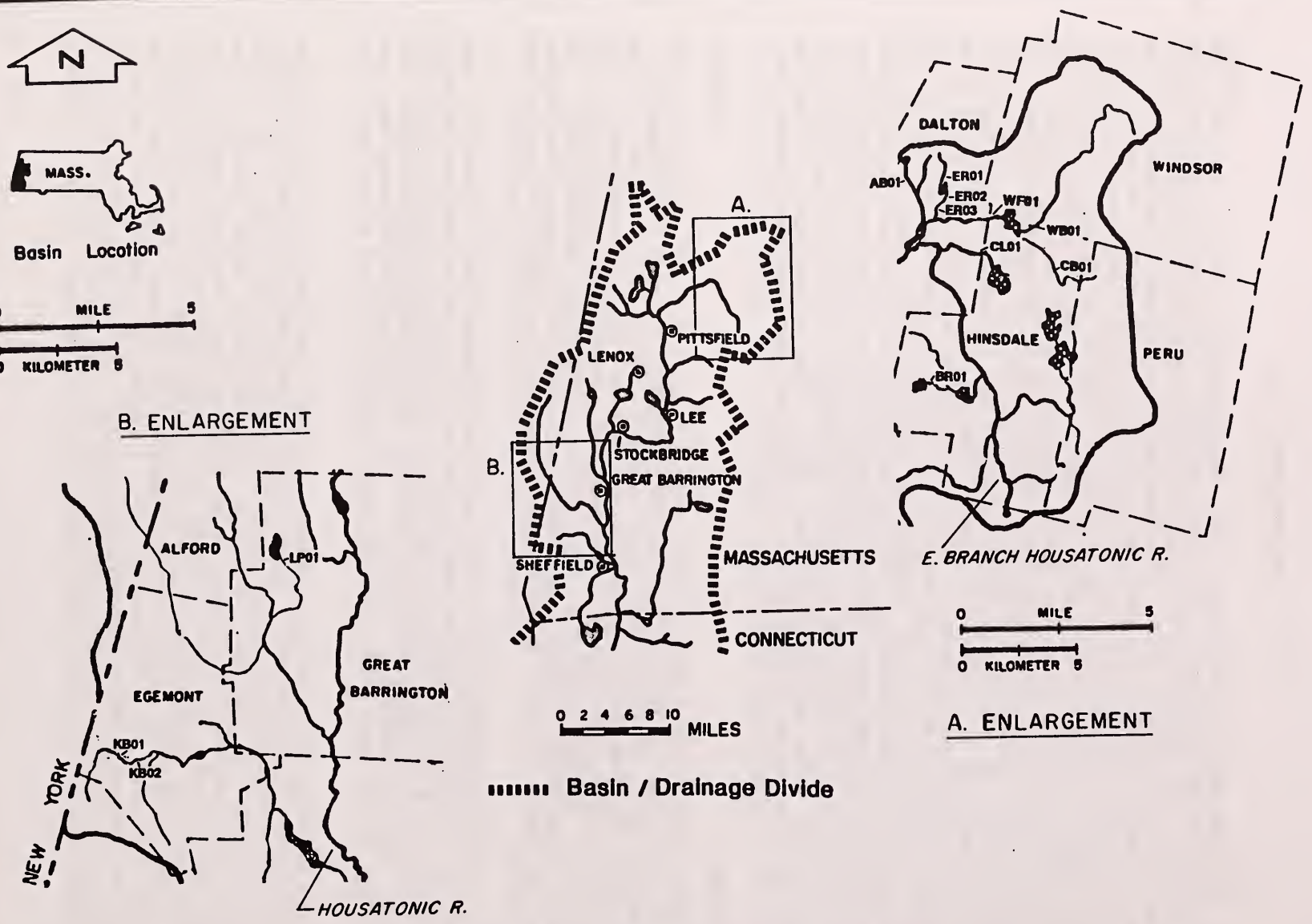

FIGURE 1. Housatonic River Tributary Biomonitoring Stations

Three sampling stations were located along the Egypt Brook system: a reference station in the inlet stream (ER01), a test station located just downstream from the outlet of Egypt Reservoir (ER02), and a test station located between the confluence of the Little Egypt Reservoir overflow with Egypt Brook and Holiday Road in Dalton (ER03). Since there was no inlet stream to Anthony Pond, and the water withdrawal from the pond was pumped into the Little Egypt Reservoir, the reference station for the Anthony Brook test station (AB01) was the same as for the Egypt Brook system (ER01).

Windsor Reservoir is another water supply source for the Dalton Fire District. The reservoir receives flow from Cady Brook which originates at the confluences of several unnamed feeder streams in Peru. Cady Brook is third-order at its crossing of New Windsor Road in Hinsdale and soon empties into Windsor Reservoir. Windsor Reservoir also receives flow from an unnamed first-order tributary which originates on the eastern side of Weston Mountain in Dalton. At one time Windsor Reservoir also received flow from Windsor Brook (and perhaps still does on an intermittent basis), which originates in the Windsor State Forest. Windsor Brook (Figure 1), which becomes third-order at its confluence with the Tyler Brook system, is then diverted through an aqueduct into the Cleveland Brook Reservoir leaving a dry streambed for approximately a quarter mile. The outlet of Windsor Reservoir, Wahconah Falls, marks the beginning of Wahconah Falls Brook, a third-order stream. The brook receives flow from Weston Brook and Egypt Brook before its confluence with Center Pond and the East Branch Housatonic River. The Wahconah Falls Brook test station (WF01), located downstream from the Windsor Reservoir, was evaluated using the reference station on Cady Brook (CB01).

Cleveland Brook Reservoir supplies the Pittsfield Water Company and the Dalton Fire District. The reservoir receives flow from two first-order unnamed tributaries as well as the flow from the Windsor Brook aqueduct. The outlet of the reservoir, Cleveland Brook, joins the East Branch Housatonic River about one-half mile upstream from Center Pond. The test station location on Cleveland Brook (CL01) was compared to the Cady Brook regional reference station (CB01).

The first-order stream originating at the outlet of Belmont Reservoir in Hinsdale is joined by Welch Brook prior to its confluence with Plunkett Reservoir. The station located downstream from Belmont Reservoir (BR01) was considered physically similar to the Egypt Brook system. The inlet stream to Egypt Reservoir (ER01) therefore served as the reference for BR01.

Long Pond in Great Barrington lies on the southeastern side of Tom Ball Mountain. The outlet stream of this man-made pond, which is indicated as a perennial first-order stream on the U.S. Geological Survey maps, was dry except for a few isolated pools at various locations along the streambed. The outlet structure of the pond was approximately six inches higher than the water level. Sampling downstream from this water supply withdrawal was, therefore, not possible.

Karner Brook, which originates on the northern side of Mount Washington, is a first-order perennial stream. The South Egremont Water Company withdrawal is directly from the stream, above a small dam. The water passes through one of two sand filter beds and any overflow is discharged back to the brook. The Karner Brook withdrawal was evaluated using a reference station located approximately 0.2 miles upstream from the water withdrawal site (KB01) and the test station just downstream from the water supply structure (KB02).

METHODS

Sampling station locations are described in Table 1. Methods used to evaluate the effects of the water withdrawals included stream flow measurement and physicochemical water quality sampling, in addition to the methods outlined in Protocols II and V in "Rapid Bioassessment Protocols For Use In Streams And Rivers - Benthic Macroinvertebrates And Fish" (Plafkin et. al. 1989). These protocols will hereafter be referred to as RBP II and V. Each component of the field survey plan is briefly described below.

Table 1
1992 Housatonic River Tributary Biomonitoring Survey
Station locations

Station	Station Description	Station Status	Survey Date
ER01	Tributary stream into Egypt Reservoir, Dalton	Reference	4 August
ER02	Outlet stream from Egypt Reservoir, Dalton	Test	4 August
ER03	Outlet stream from Egypt Reservoir near Holiday Road, Dalton	Test	4 August
AB01	Anthony Brook off Anthony Road, Dalton	Test	4 August
CB01	Cady Brook off New Windsor Road, Hinsdale	Regional Reference	5 August
WB01	Windsor Brook off Windsor Road, Hinsdale	Regional Reference	5 August
WF01	Wahconah Falls Brook at Wahconah Falls State Park, Hinsdale	Test	5 August
CL01	Cleveland Brook at Old Windsor Road, Dalton	Test	5 August
BR01	Outlet of Belmont Reservoir, Hinsdale	Test	3 August
KB01	Karner Brook off Mount Washington Road, Egremont	Reference	6 August
KB02	Karner Brook off Mount Washington Road, Egremont	Test	6 August
LP01	Outlet of Long Pond, Great Barrington	Test	Not Done

Stream flow

Stream flow gaging was conducted using a low-flow Swoffer meter (model 2100) according to the procedures outlined in the "Basins program standard operating procedures river and stream monitoring" (TSB 1989). A transect within each sampling site with the most laminar flow was selected for gaging. Water velocity and stream depth measurements were taken at select intervals along the transect at a depth of (0.4)(stream depth) and recorded on standard flow gaging field sheets. Data reduction and stream discharge were calculated back at the TSS office. The stream flow gaging component of this survey was included in an

attempt to quantify the summertime base-flow conditions in the vicinity of the surface water withdrawals.

Physicochemical

Stream temperature and pH measurements were made in situ at each station with a hand-held alcohol pocket thermometer and an Orion model dual-buffer pH meter, respectively. Procedures used for bottle preparation, sampling technique, and sample handling are outlined in the Basin Program SOP (TSB 1989). A dissolved oxygen sample was collected and fixed at each station. Discrete grab samples for chemical analyses (alkalinity, hardness, suspended and total solids, turbidity, and chlorides), nutrients (including Total Kjeldahl, ammonia- and nitrate-nitrogen and total phosphorus), and total and dissolved metals (Al, Cd, Cr, Cu, Fe, Hg, Ni, Zn, As, and Pb) were also collected directly from the stream at each sampling location. The samples were preserved as necessary and were transported on ice to the Lee POTW laboratory, which was being used as the field laboratory during the 1992 Housatonic River Survey. The dissolved oxygen samples were titrated according to the azide modification of the Winkler method (TSB 1989) at the Lee POTW laboratory. Filtration of the dissolved metal samples was also conducted at the Lee POTW laboratory, after which the samples were preserved. The samples were transported to the Lawrence Experiment Station (LES) where they were analyzed according to American Public Health Association (APHA) approved methods (Greenberg et al. 1992). Quality control data and procedures are on file at the LES laboratory.

Water chemistry data collected during the biomonitoring survey were compared to the Class A and B Cold Water Fishery standards (MA DEP 1990), depending upon the classification assigned to the stream reach sampled. In addition to conventional pollutant parameters, the newly revised standards have adopted EPA-recommended water quality criteria for toxic pollutants. Altogether, these criteria were used to help determine whether or not the streams were supporting their designated uses.

Habitat Assessment

An integral component of both RBP II and V is an assessment of the available habitat at each station. Physical characteristics of the stream substrate, channel morphology, and the structural stability of the stream banks are scored according to the methods outlined in the RBP manual (Plafkin et. al. 1989). The percent comparability between the reference station and the test station habitat scores are then utilized to help determine if a change in the biota is due to impacts other than habitat differences. An inventory of the predominant riparian and aquatic vegetation at each site was also included as part of the overall habitat assessment.

Aquatic Macroinvertebrates (RBP II)

RBP II involves the collection of a 100-organism subsample of macroinvertebrates collected via D-frame kick-net sampling in two square meters of riffle. The organisms were sorted and identified to family level in the field, and the identifications were later verified back at the DWPC-TSS office. Coarse particulate organic matter (CPOM) sampling to determine shredder abundance was excluded from the RPB II protocol. Analysis of the macroinvertebrate data followed the procedures outlined in RBP II. Seven of the eight metrics were utilized to classify the biological condition of the macroinvertebrate communities as non-impaired, moderately impaired, or severely impaired.

Fish (RBP V)

Fish communities were sampled at each station using a battery-powered backpack electroshocking unit (Smith Root Model 12). Before sampling commenced, block seines were set at the upstream and downstream ends of each stream reach sampled

unless physical barriers for migration were present. The nets were set prior to any other instream activity at each site. Collections were made in a representative stream reach (containing riffle, run, and pool habitat when available) measuring approximately 100 meters (125 meters at KB01 and KB02). Only one pass was made with the electroshocking unit due to the relatively small size of most streams sampled and the high percent of capture estimated during that pass. All fish were held in plastic buckets for subsequent identification, enumeration, and release. Voucher specimens were retained and preserved when field identifications were questionable.

Due to the fact that the USEPA RBP V calls for analysis of the data generated from fish collections using an established Index of Biotic Integrity (IBI) similar to that described by Karr (1986), a version of the IBI developed and currently being used by personnel in the State of Vermont (Langdon 1992) was employed. This version of an IBI has been tested and used extensively in the higher elevations of the ecoregion known as the Northeastern Highlands (NEH) (Omernick 1987). The NEH includes the Berkshires and the Housatonic River Basin.

While the original intention was to score the fish communities at each station using the Vermont IBI, it became clear following actual employment of the method, and discussions with Langdon of the State of Vermont, that this would not be possible. The Vermont IBI is designed to show changes in fish community structure resulting from various impacts including nutrient enrichment or toxics, and habitat impacts such as siltation or water withdrawal. One condition for use of the Vermont IBI is that three non-salmonid species must be present. Unfortunately, in small headwater tributaries in the mountainous regions of New England, typical fish assemblages contain only one, two, or three species. Usually one of these is a trout, either eastern brook or brown. Langdon (personal communication) has found that in situations where there is a limited number of species present, the IBI loses its utility, and a straight density calculation may be more appropriate. Density calculations and subjective analysis were therefore employed to analyze the fish data from those stations not supporting three non-salmonid species. Surface areas of the sampling stations were calculated using the mean width of the stream in the sampling reach multiplied by the length of the stream reach sampled. Fish density was then reported as the # fish/100 m^2.

RESULTS

Stream discharge measurements taken during the 1992 Housatonic River Tributary Biomonitoring Survey are summarized in Table 2. Stream discharge was used to calculate a flow factor defined as discharge per one square mile of drainage area (cfs/mi^2). Unfortunately, the weather conditions were unfavorable. Heavy rainfall occured during the survey of the Egypt/Anthony Brook systems, in particular, while nighttime thundershowers also augmented the flows in the other streams sampled.

The range of flow factors in the first order streams was 0.15 to 5.01 cfs/mi^2 while that of the third order streams was between 1.00 and 2.37 cfs/mi^2 during the time of the survey.

Percent saturation of oxygen and stream temperature (Table 3) at all of the stations sampled met the water quality standard for Class A waters (MA DEP 1990). The pH values at three of the sites, however, were below 6.0 (Table 3): 4.6 in the inlet stream to Egypt Reservoir (ER01), 5.3 in Anthony Brook (AB01), and 5.7 in Wahconah Falls Brook (WF01).

The total alkalinity and hardness levels in all of the streams sampled were low, although particularly low in the Egypt Brook and Anthony Brook systems (Table 4) where the alkalinity values ranged between <minimum detection limit (MDL) to 6.5 mg/l, and the hardness values ranged from 7.5 to 17 mg/l as $CaCO_3$. Cleveland

TABLE 2
1992 Housatonic River Tributary Biomonitoring Survey
Stream discharge data

Station	Drainage Area (mi^2)	Mean Velocity (fps)[1]	Discharge (cfs)[2]	Flow Factor (cfs/mi^2)
ER01	0.40	0.35	1.573	3.93
ER02	0.73	0.77	3.532	4.84
ER03	0.83	0.38	4.155	5.01
AB01	0.53	0.32	1.820	3.43
CB01	2.9	0.41	3.835	1.32
WB01	9.52	0.65	22.549	2.37
WF01	5.69	0.49	11.328	1.99
CL01	1.3	0.37	1.298	1.00
BR01	0.55	0.05	0.085	0.15
KB01	1.74	0.32	0.726	0.42
KB02	2.0	0.43	0.697	0.35

[1] fps = feet/second.
[2] cfs = cubic feet/second.

Brook and the downstream station on Karner Brook (KB02) were found to have the highest alkalinity values. In all cases except KB02, alkalinity was lower than hardness, and therefore is indicative of noncarbonate hardness (Lind 1974).

The total and suspended solids content was very low at each sampling station; the highest total solids concentration found was at CL01 (126 mg/l), although the suspended solids were very low (4.5 mg/l). Overall, the suspended solids concentrations at all of the stations sampled ranged between <1 and 18 mg/l while total solids ranged from 16 to 126 mg/l. Similarly, turbidity was quite low (i.e., <1.0 NTUs) at all stations except for station ER01. The rainfall occurring just prior to the survey may have been partially responsible for the slightly higher turbidity measurement of 1.2 NTUs at this station.

All nutrient levels (TKN, ammonia and nitrate nitrogen, and total phosphorus) were extremely low. Violations of the water quality standards were not encountered since none of the TKN measurements exceeded 0.70 mg/l nor was total phosphorus detected in any of the samples.

Chloride concentrations were quite low at all stations. The stations with the highest chloride concentrations were AB01 (31 mg/l) and CL01 (10 mg/l).

The total metals data (Table 5) were compared to the EPA chronic four-day average criteria promulgated in the standards (MA DEP 1990). Where appropriate, the data were compared to the criteria which were adjusted for the site specific hardness. A listing of the national metals criteria are provided in Appendix A. Twenty-eight percent of the total metals analyses exceeded their chronic criterion. Futhermore, over half (58%) of the total metals samples exceeding the chronic criteria were from the Anthony Brook/Egypt Reservoir systems. Figure 2 illustrates the magnitudes of exceedance of the EPA chronic criteria at each station through the use of toxic unit (TU) calculations. Toxic units are simply the concentration of chemical i divided by the chronic criterion of chemical i. According to the Massachusetts water quality standards (MA DEP 1990), TUs > 1.0 are in violation.

TABLE 3
1992 Housatonic River Tributary Biomonitoring Survey
pH, temperature and oxygen data

Station	Sampling Date	Sampling Time	pH	Temperature (°C)	Dissolved Oxygen (mg/l)	% Saturation
ER01	4 August 1992	1000	4.6	11	9.9	89
ER02	4 August 1992	1145	6.1	19	8.6	91
ER03	4 August 1992	1415	6.7	17	8.8	91
AB01	4 August 1992	1620	5.3	14	9.0	87
CB01	5 August 1992	1530	6.8	16	8.6	86
WB01	5 August 1992	1334	7.5	16	8.6	86
WF01	5 August 1992	1045	5.7	19	8.5	90
CL01	5 August 1992	1140	7.6	14	8.8	85
BR01	3 August 1992	1315	6.9	13	9.2	87
KB01	6 August 1992	0935	7.3	13.5	9.8	94
KB02	6 August 1992	0930	7.4	13	9.6	91

Several of the dissolved metals were found to be in excess of the total metals concentrations; particularly chromium and zinc, although half of the metals samples from ER01 exhibited this phenomenon. Since the samples were all collected directly from the stream, not split samples, concentrations of various substances may have fluctuated due to the wet weather sampling conditions.

The available habitat quality at each of the sampling stations is described and briefly summarized in Tables 6 and 7, respectively. All of the stations had habitat quality $\geq$ 90% comparable to the reference stations'. The Cleveland Brook station scored the lowest overall (102 out of a possible 135 score), primarily due to sand bar formation from road runoff to the streambed. Habitat quality would not be considered to be the cause of any impairment in the overall biological assessment at any of the sampling stations. The inventory list of predominant riparian and aquatic vegetation recorded at each sampling station is provided in Appendix B.

The macroinvertebrate communities at all of the stations sampled were considered non-impacted under current conditions (see Figure 3). The RBP II sampling provided an inventory of the resident community components at each station (Appendix C). The communities tended to be rich in "pollution-intolerant" groups, that is, a generally healthy and diverse assemblage (Table 8). However, the absence of ephemeropterans at the reference station ER01 and the hyperdominance (54%) of an ephemeropteran family at KB01 indicates that both reference stations may be stressed. A summary of the metric scores for the RBP II and the overall assessment of the macroinvertebrate communities is contained in Table 9.

The results of fish population sampling can be found in Table 10. The number of species collected ranged from zero at station ER01 to eight at station WF01. All fish collected can be considered true stream species except for two species collected at station WF01. All specimens considered pond species (largemouth bass *Micropterus salmoides*, and yellow perch *Perca flavescens*) were young-of-the-year (YOY) fish.

TABLE 4
1992 Housatonic River Tributary Biomonitoring Survey
Physicochemical data (results reported in mg/l unless otherwise noted)

Parameter	ER01	ER02	ER03	AB01	CB01	WB01	WF01	CL01	BR01	KB01	KB02
alkalinity	1.7	1.8	6.5	<MDL[a]	11	27	28	63	17	36	75
hardness	7.5	8.4	17	8.6	14	35	34	72	28	48	48
suspended solids	2.5	<1	3.5	4.0	1.5	5.0	2.5	4.5	18	<1	<1
total solids	34	16	22	26	30	72	54	126	74	72	56
turbidity[b]	1.2	0.3	0.4	0.4	0.7	0.7	0.8	0.4	0.5	0.2	0.2
TKN	0.38	0.09	0.16	0.27	0.55	0.34	0.26	0.22	0.70	0.09	0.09
ammonia-N	0.08	<0.02	<0.02	<0.02	0.03	0.04	<0.02	0.03	<0.02	<0.02	<0.02
nitrate-N	0.63	0.15	0.15	<0.02	0.09	0.05	0.04	0.15	0.16	0.36	0.33
total phosphorus	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
chloride	<1	<1	<1	31	<1	1.0	3.0	10	2.0	8.0	7.0

[a] MDL = 1.0 mg/l
[b] Results reported in NTU

TABLE 5
1992 Housatonic River Tributary Biomonitoring Survey
Summary of total and dissolved metals data
(Results reported in mg/l)

Parameter	ER01	ER02	ER03	AB01	CB01	WB01	WF01	CL01	BR01	KB01	KB02
Aluminum	0.90	0.30	0.26	0.38	0.08	<0.05	<0.05	0.19	<0.05	<0.05	<0.05
d* Aluminum	1.0	0.19	0.16	0.28	0.06	<0.05	<0.05	<0.05	--	<0.05	<0.05
Cadmium	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
d Cadmium	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.003	<0.001	--	<0.001	<0.001
Chromium	<0.001	<0.03	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
d Chromium	<0.001	0.04	0.04	<0.001	0.03	<0.001	<0.001	<0.001	--	<0.001	<0.001
Copper	<0.002	<0.002	0.06	0.03	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
d Copper	0.004	0.007	<0.002	<0.002	<0.002	0.002	<0.002	<0.002	--	<0.002	<0.002
Iron	0.14	0.15	0.29	0.24	0.57	0.21	0.20	0.45	1.2	<0.03	<0.03
d Iron	0.15	0.06	0.10	0.08	0.33	0.17	0.21	0.09	--	<0.03	<0.03
Mercury	0.0004	0.0003	0.0003	0.0009	<0.0002	<0.0002	<0.0002	0.0003	<0.0002	0.0005	0.0004
d Mercury	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	--	<0.0002	<0.0002
Nickel	<0.003	<0.003	0.09	0.021	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003
d Nickel	<0.003	<0.003	0.03	0.006	<0.003	<0.003	<0.003	<0.003	--	<0.003	<0.003
Zinc	0.03	0.04	0.02	0.06	0.05	0.02	0.012	0.03	0.06	0.04	0.008
d Zinc	0.06	0.03	0.02	0.02	0.02	0.011	0.03	0.05	--	<0.005	0.02
Arsenic	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
d Arsenic	0.007	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	--	<0.001	<0.001
Lead	0.07	0.09	0.08	0.07	0.007	0.006	0.007	0.08	0.007	<0.002	0.05
d Lead	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	--	<0.002	<0.002

* d = dissolved
-- Sample lost.

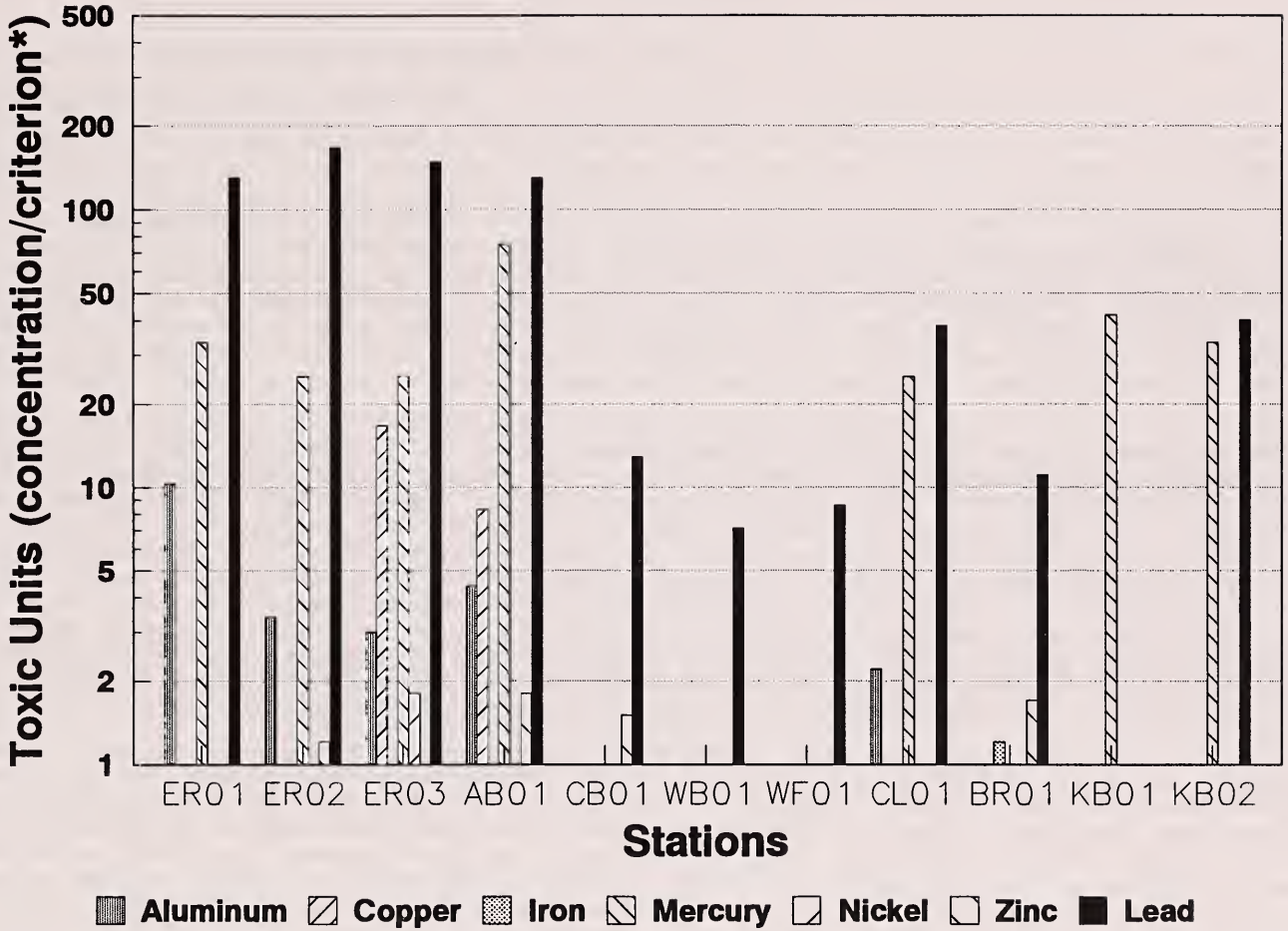

FIGURE 2. Exceedances of chronic aquatic life criteria expressed in terms of toxic units using the total metals data from the Housatonic River Tributaries.

TABLE 6
1992 Housatonic River Tributary Biomonitoring Survey
Station descriptions and habitat assessments

Station	Description and Habitat Assessment
ER01	The physical habitat present at this site was excellent. The streambed consisted primarily of cobble and gravel with some boulders present. The stream reach sampled was located in a remote forested area which shaded 95% of the stream. Hemlock predominated the overstory, with red spruce, maples, birch and hobblebush common. There were no visible signs of either watershed erosion or non-point source pollution although the banks along the eastern side of the stream were steep. The stream reach sampled offered a variety of habitat including fast and slow and deep and shallow pools and riffles. Quartzite, a metamorphizied sandstone, was also abundant in the stream and surrounding area. The stream width varied between 1.8 and 3.7 m, while the depth ranged from 0.1 to 0.2 m in the riffles and up to 0.8 m in the pools.
ER02	The stream reach sampled provided excellent substrate including boulder, cobble, and gravel, although not quite as much cover was available as at ER01. This section of Egypt Reservoir Brook had some sand deposits in the bend areas, indicating the potential for slight impacts due to local watershed erosion. While the eastern streambank was wooded and very steep, the opposite bank was buffered by only a 1.8 m stretch of trees and shrubs. Hemlock was dominant. Yellow birch and maples were present. Adjacent to this buffer the topography of the area was flat, apparently from construction activities associated with the water supply piping from Egypt Reservoir to the Little Egypt filtering station. Altogether, the canopy cover provided shade to approximately 40% of the stream. Instream habitat variety was also excellent in the reach sampled. Stream width varied between 1.2 and 3.7 m while stream depth ranged from 0.05 to 0.3 m in the riffles and up to 0.8 m in the deeper pools. A series of small cascading waterfalls, pools, and runs with riffle areas were scattered throughout.
ER03	Habitat and available cover in this stream reach were excellent. Boulder, cobble, and gravel substrate made up the majority of the streambed and there was no evidence of any non-point source pollution or local watershed erosion. The streambanks were stable and the canopy provided by the forest provided shade to the entire stream reach sampled. Hemlock and a variety of hardwoods predominated. The stream width was fairly uniform at approximately 3.7 m. The boulder type waterfalls, and mixed riffle/run habitat provided stream depth ranging from 0.2 m in the riffles to 0.6 m in pools.

TABLE 6 (Continued)

Station	Description and Habitat Assessment
AB01	The habitat and cover provided at this station was excellent, although some potential sources of non-point source pollution and local watershed erosion were identified due to the logging activities currently occuring in the vicinity of the stream. The canopy cover of the surrounding forest provided shade to approximately 80% of the stream reach sampled. The dominant forest tree was hemlock. Birch, maples, beech and white ash were common. The streambed, consisting of primarily gravel, boulder and cobble was also noted to have some sand deposits, although embeddedness of the substrates was not a problem. The stream provided a variety of deep and shallow habitats including both riffle and pool areas. Stream width was anywhere between 0.8 and 3.0 m while depth varied between 0.05 and 0.1 m in the riffles to 0.8 m in the pools.
CB01	The stream reach was characterized as having excellent habitat including boulder, cobble, and gravel substrates with some sand deposits along with excellent cover. There was evidence of some non-point source pollution from road runoff, however, noted in terms of the slight embeddedness of the bottom substrates with fine sediment. The stream reach, which was 98% shaded, was noted to have moderately stable banks, and good streamside cover. The overstory was predominated by hemlock, yellow and black birch, beech, and maples. The stream provided a variety of available habitat which included shallow riffles and deep pools. The stream width varied from 2.4 to 3.7 m. Depth ranged from 0.1 m in riffles to 1.2 m in pools.
WB01	The bottom substrates of Windsor Brook were comprised of primarily cobble with boulder and gravel and were considered excellent habitat. Available cover, although stable, was considered good. There were no visible signs of any watershed erosion or non-point source pollution problems. This was evidenced by the lack of any instream sand deposits or embeddedness of bottom substrates with silt. The canopy cover was primarily open leaving only 10% of the stream shaded. Shoreline vegetation included various ferns, sedges, yellow loostrife, clotbur and Joe-pye-weed. Stream depth ranged between 0.3 and 0.9 m in the riffles and pools, respectively, while the stream width was fairly uniform at approximately 7.6 m.

TABLE 6 (Continued)

Station	Description and Habitat Assessment
WF01	Habitat in terms of bottom substrate and available cover were considered excellent in the stream reach sampled. The bottom substrates were comprised primarily of boulder with bedrock, cobble, gravel and sand comprising the remainder of the substrate in equal proportions. Aquatic mosses were present on some rock substrates. There was no evidence of substrate embeddedness in the stream reach sampled; however, non-point source pollution problems were evident due to road erosion and parking lot runnoff adjacent to this site. Washout channels filled with sand and silt were present at the lower end of the parking area. The stream reach sampled, however, was divided by an island and served to separate the sampling area from the erosion problems. Although both streambanks were relatively steep, there was no evidence of any streambed alteration or deposition of road runoff in the sampling area. The stream reach was approximately 50% shaded by a variety of tree species including hemlock, hornbeam, sugar maples, yellow and white birch. The stream width of the reach sampled ranged between 4.6 and 5.8 m with water depths ranging from 0.2 m in the riffles and runs up to 1.4 m in the pools. The stream provided a diversity of habitat including deep and shallow riffles and pools. Periphyton growth on the bottom substrate resulted in slick wading conditions.
CL01	The bottom substrates in this sampling area were considered excellent although they contained the highest percentage of sand of all of the stations sampled. Boulder, cobble, gravel, and sand all contributed fairly evenly to the distribution of the substrates. Aquatic mosses occurred on some rocks. Although embeddedness of the bottom substrates was not a problem, local watershed erosion and non-point source pollution effects of surface runnoff were evidenced by stream channel alterations, bottom scouring, and depositional areas of sand. These factors were responsible for lowering the overall habitat assessment score. The station was bordered by forest along with a few residential homes. The stream was primarily shaded by a canopy comprised of hemlock, american hop hornbeam, striped maple and hobblebush except for its crossing by Old Windsor Road. The stream reach sampled contained riffles, runs, and pools which ranged between 0.2 to 0.6 m in depth. The stream width averaged 1.8 m and was slightly wider at its bends.
BR01	The first order upper perennial stream reach sampled was located in a completely forested area, which completely shaded the stream, at a distance of approximately 1/4 mile downstream from Belmont Reservoir. The streambed substrates of boulder, cobble, gravel, and some sand, provided excellent habitat, while downed trees and undercut banks provided both diverse and stable cover. Instream habitat was also varied with riffles between 0.05 and 0.2 m, and a few 0.3 m deep pools between runs. Aquatic mosses were common along the streambanks. There was no evidence of any local watershed erosion or non-point source pollution although there were a few slightly silted areas in the stream. Steep slopes bordered the stream on its southern bank while the northern slope had less pitch. Common tree species included hemlock, yellow birch, beech, striped and sugar maple, and white ash. The stream ranged between 0.3 to 1.8 m in width although the channel (high water marks) was approximately 2.7 m. Bank stability, however, was considered good.

TABLE 6 (Continued)

Station	Description and Habitat Assessment
KB01	The upstream segment of Karner Brook provided excellent habitat and cover. The stream gradient was very steep and the bottom substrates were comprised primarily of cobble with bedrock, boulder, gravel and sand in relatively equal proportions. There was no evidence of any local watershed or non-point source pollution problems along the partially shaded stream reach, although the stream banks on the southern side were quite steep. Birches, maples, and white ash were common.The stream provided both deep and shallow riffle, run and pool stretches as it cascaded over small boulder and bedrock falls with depths ranging from 0.05 to 0.1 m in the riffles to 0.5 m pools. The stream width averaged approximately 1.7 m.
KB02	The downstream segment of Karner Brook provided excellent substrate and good cover. The streambed was comprised of 50% cobble substrate along with boulders, gravel, and a small amount of sand. Aquatic mosses were present on some rocks. Slight siltation was also present although substrate embeddedness was not a problem. The stream reach sampled provided diverse habitat including deep and shallow riffles and pools. Canopy vegetation included hemlock, aspen, yellow and black birch, and white ash. Stream depth ranged from 0.08 to 0.2 m in the riffles to 0.3 m pools while stream width varied between 0.3 and 0.9 m. Local watershed erosion from slightly unstable streambanks and non-point source pollution problems from road runoff were identified. Despite its pristine location, intermittant waves of sewage-type odors were present, originating, at least in part, from mats of filamentous algae (Lyngbya) located in the pooled area just upstream from the water supply structure.

TABLE 7
1992 Housatonic River Tributary Biomonitoring Survey
Summary of habitat evaluations

Habitat Parameter	Rank	ER01	ER02	ER03	AB01	CB01	WB01	WF01	CL01	BR01	KB01	KB02
Bottom Substrate	Excellent	x	x	x	x	x	x	x	x	x	x	x
Available Cover	Excellent	x	x	x	x	x		x		x	x	
	Good						x		x			x
Embeddedness	Excellent	x	x	x	x		x	x	x	x	x	x
	Good					x						
Velocity/depth	Excellent	x	x	x	x	x	x	x	x	x	x	x
Channel alteration	Excellent	x	x	x	x	x	x	x		x	x	x
	Fair								x			
Bottom scouring and deposition	Excellent	x	x	x	x	x	x	x		x	x	x
	Good								x			
Habitat variety	Excellent	x	x	x	x		x	x			x	
	Good					x			x	x		x
Bank stability	Excellent			x	x							
	Good	x	x			x	x	x	x	x	x	x
Bank vegetative stability	Excellent	x		x		x	x	x		x	x	x
	Good		x		x				x			
Streamside Cover	Good	x	x	x	x	x	x	x	x	x	x	x
Overall Habitat Assessment Score		130	122	128	128	112	126	125	102	120	120	116
Percentage of Reference Condition		100 (R)	94	98	98	100 (R)	100 (R)	90	91	92	100 (R)	97

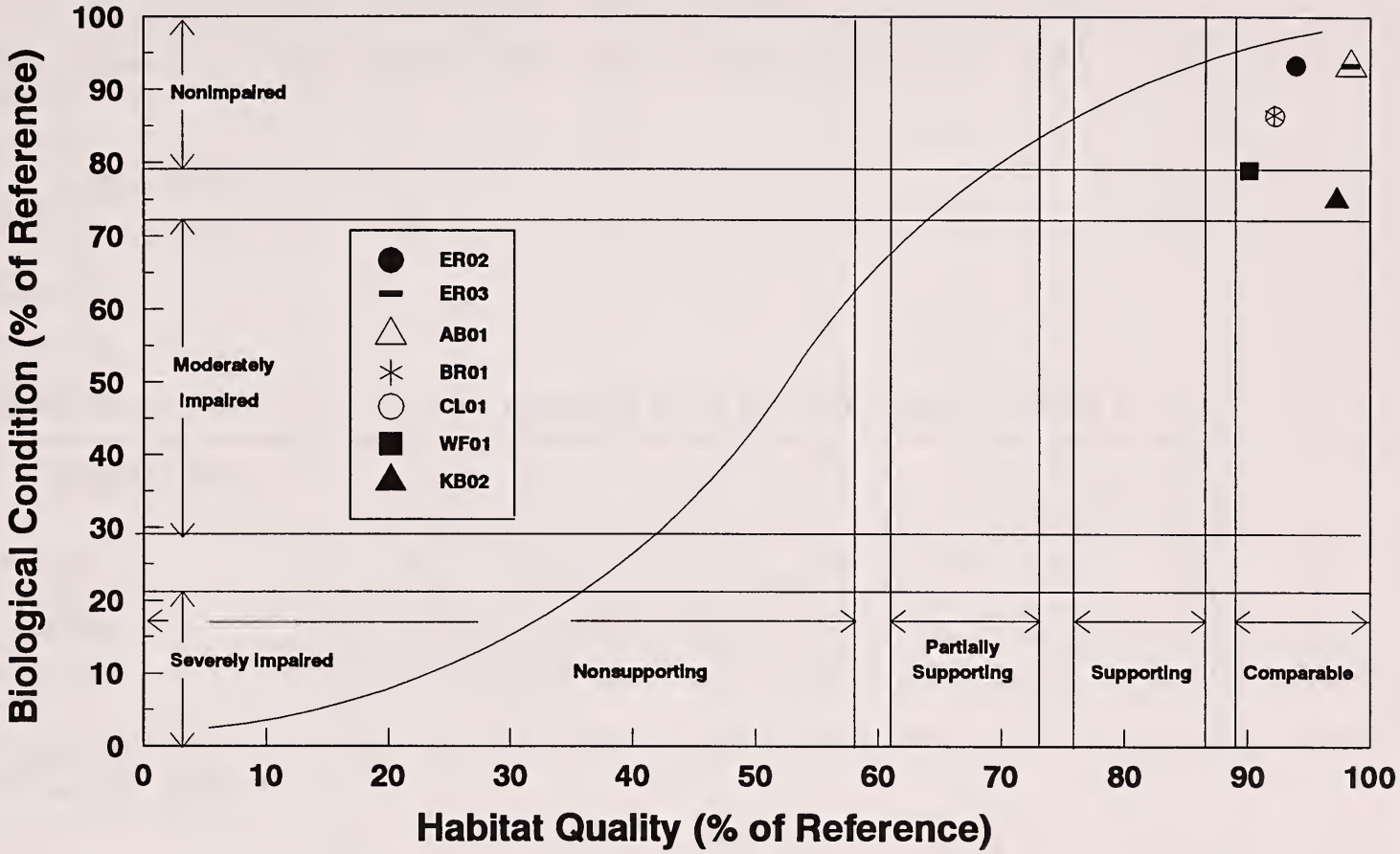

FIGURE 3. Habitat Quality and condition of benthos at test stations in the Housatonic River Tributaries.

TABLE 8
1992 Housatonic River Tributary Biomonitoring Survey
RBP II data summary sheet

Parameter	ER01	ER02	ER03	AB01	CB01	WB01	WF01	CL01	BR01	KB01	KB02
Taxa Richness	13	20	21	16	18	20	21	17	14	13	21
FBI (modified)	3.41	2.36	3.38	2.88	3.74	3.24	3.60	3.58	2.49	3.29	2.92
Functional Feeding Groups Riffle Community Scrapers/Filt. Collect.	0.05	1.8	0.62	0.62	0.25	2.7	1.41	1.56	0.34	20.67	1.59
CPOM Community Shredders/Total	0.41	0.31	0.15	0.28	0.22	0.11	0.18	0.18	0.44	0.08	0.19
EPT/Chironomidae	2.1	3.94	2.68	2.5	1.93	3.38	4.27	3.87	0.17	10.5	2.4
% Contribution (dom. family)	29	24	22	26	26	21	17	15	32	54	20
EPT Index	8	11	13	12	12	13	11	10	9	9	12
Community Similarity Index (% Sim.)*	--	39	42	61	--	--	50	62	35	--	35

* % sim = Σ min(a,b) where a = % of taxon in sample A and b = % of taxon in sample B.

TABLE 9
1992 Housatonic River Tributary Biomonitoring Survey
RBP II scoring sheet

Parameter	ER01	ER02	ER03	AB01	CB01	WB01	WF01	CL01	BR01	KB01	KB02
Taxa Richness	6	6	6	6	6	6	6	6	6	6	6
FBI (modified)	6	6	6	6	6	6	6	6	6	6	6
Functional Feeding Groups Riffle Community Scrapers/Filt. Collect.	6	6	6	6	6	6	0	6	6	6	0
CPOM Community Shredders/Total	--	--	--	--	--	--	--	--	--	--	--
EPT/Chironomidae	6	6	6	6	6	6	6	6	6	6	0
% Contribution (dom. family)	6	6	6	6	6	6	6	6	3	0	6
EPT Index	6	6	6	6	6	6	6	3	6	6	6
Community Similarity Index	--	3	3	3	--	--	3	3	3	--	3
Total Score	42	39	39	39	42	42	33	36	36	36	27
% Comparability to Reference Station	--	93	93	93	--	--	79	86	86	--	75
Overall Assessment	--	N-I*	N-I	N-I	--	--	N-I	N-I	N-I	--	N-I (border line)

* N-I refers to Non-Impacted.

TABLE 10
1992 Housatonic River Tributary Biomonitoring Survey
Fish population and density data

Species Code[1] and Number of Fish Collected (# young-of-the-year)

Station	EBT	SS	LND	BND	BT	CS	YP	LMB	Fish Density[2]
ER01	(no fish collected or observed)								0
ER02	10								6
ER03	6 (15)								12
AB01	12 (5)								8
CB01	31 (16)			26	1				39
WB01	15			1					N/C[3]
WF01	3	24	22	14	10	5	(3)	(1)	19.7
CL01	24 (20)		1		29 (2)				49.5
BR01	13	1							8.3
KB01	28 (24)								27
KB02	18 (1)	12 (>15)							30

	Common Name	Scientific Name
[1] EBT	eastern brook trout	*Salvelinus fontinalis*
SS	slimy sculpin	*Cottus cognatus*
LND	longnose dace	*Rhinichthys cataractae*
BND	blacknose dace	*Rhinichthys atratulus*
BT	brown trout	*Salmo trutta*
CS	common shiner	*Notropis cornutus*
YP	yellow perch	*Perca flavescens*
LMB	largemouth bass	*Micropterus salmoides*

[2] reported as number of fish/100m^2 (does not include young-of-the-year)

[3] not calculated

The efficiency of the electroshocking effort was rated as excellent (capture estimated at >90%) at all but two of the stations. Electroshocking at WB01 was rated poor (capture estimated at 50%) due to the width of the stream. Two electroshockers would have been more appropriate at this site. Electroshocking at WF01 was rated as good (capture estimated at 75%), due to visibility problems caused by slightly darker water color, and closed canopy, as well as footing problems caused by increased occurrence of periphyton--resulting in slick wading conditions.

Station ER01 was totally devoid of fish. Four of the ten stations (ER02, ER03, AB01, and KB01), from which fish were collected, contained only eastern brook trout *Salvelinus fontinalis*. Five additional stations (CB01, WB01, CL01, BR01, and KB02) contained only one or two other species. Two of those stations, CB01 and CL01, had brown trout *Salmo trutta* and one dace species *Rhinichthys sp.* while two other stations, BR01 and KB02, contained slimy sculpins *Cottus cognatus* in addition to the eastern brook trout. Only blacknose dace *R. atratulus* and eastern brook trout were observed at station WB01.

Stream species present at station WF01 included eastern brook trout, brown trout, slimy sculpin, longnose dace *R. cataractae*, blacknose dace, and common shiner *Notropis cornutus*. The fish community at this station was assessed as excellent (Table 11) using the metrics and scoring criteria outlined in the Vermont IBI (Appendix D).

Since the remaining stations did not support fish communities with four non-salmonid species (Vermont IBI requirement), fish density calculations (Table 10) were used to assess the fish populations at each station. Fish density was not calculated for the WB01 site, however, due to the poor efficiency of the electroshocking effort. The fish densities ranged between zero and thirty fish per 100 m^2 in the first order streams. With the exception of the WB01 site, between 19.7 and 49.5 fish per 100 m^2 were captured in the third order streams.

DISCUSSION

ER01 - Egypt Reservoir (inlet stream)

This first order tributary to Egypt Reservoir was sampled on 4 August 1992. Heavy rains in the evening on 3 August and the morning of 4 August resulted in extreme high flows relative to the flows observed during the reconnaissance survey conducted on 7 July. The majority of the flow present appeared to be local runoff from the rain event. Although the habitat quality at this station was excellent, water quality was not. The pH of the tributary was only 4.6. Several of the heavy metals including aluminum, mercury, and lead were found in excess of their EPA chronic four-day average criteria (Figure 2 and Appendix A), while exceedances of the one-hour average (or acute) criteria were documented for aluminum and lead. Mobilization of the metals from the watershed is most likely a function of the poor buffering capacity of the soils in the area and is probably exacerbated during wet-weather conditions. The biological sampling revealed an absence of the order Ephemeroptera from the macroinvertebrate community and a fish density of zero, substantiating the physicochemical characterization of the stream.

ER02 - Egypt Reservoir (outlet stream)

The outlet of Egypt Reservoir is a first order, high gradient stream. Overflow from the cement outlet structure on 4 August was much greater than observed during the reconnaissance survey on 7 July, when underground leakage from the Reservoir appeared to make up the flow in the outlet stream. Improvement in the water quality of the stream was apparent, however, since the pH was 6.1, although metal-related toxicity could still be present considering total aluminum, mercury, zinc, and lead were detected in concentrations which exceeded their respective criteria. Habitat was rated excellent and the biological sampling

TABLE 11
1992 Housatonic River Tributary Biomonitoring Survey
Vermont IBI worksheet for WF01

METRICS	# (IBI SCORE)	SPECIES CODES[1]
1. Total number of species	5 (3)	(EBT + BT), SS, LND, BND,CS
2. Number and identity of intolerant species	3 (5)	(EBT + BT), SS, LND
3. Number and identity of benthic insectivores	3 (5)	(EBT + BT), SS, LND
4. Proportion of individuals as white suckers	0% (5)	N/A
5. Proportion of individuals as generalist feeders	6% (5)	CS
6. Proportion of individuals as insectivores	76% (5)	SS, LND, BND
7. Proportion of individuals as top carnivores	16% (5)	(EBT + BT)
8. Proportion of individuals with disease, tumors, fin damage, or other anomalies	0% (5)	N/A
9. Abundance in sample (one pass - #/100/m^2)	19.6 (5)	N/A

[1] See Table 10

showed improvement over the reference (ER01) station conditions. Ephemeropterans were found in the sample which also showed signs of a more balanced invertebrate community compared to ER01 (see Figure 4). Eastern brook trout were also captured during the electroshocking run, although some YOY fish may have been missed due to the high water conditions. Considering the available habitat, the fish density (6 fish/100m^2) was lower than any other station sampled with the exception of ER01 (Table 10). The abundance of fish at ER02 ranked intermediate according to the Vermont IBI (Appendix D), although the density would have been greater than 6 fish/100m^2 had the water level in the brook been lower. It was apparent that the fish in this reach were, at the very least, limited by low flow conditions such as those observed during the July reconnaissance survey. Metal-related toxicity may also be hampering the biota at this station, particularly during rain events.

ER03 - Egypt Reservoir (outlet stream)

Water quality at station ER03 was slightly different than at ER02 on 4 August, although heavy rainfall occurred at the time of sampling. Overflow from the Little Egypt filtering plant discharges to the outlet stream from Egypt Reservoir between stations ER02 and ER03 contributing to the higher discharge at ER03. Hardness increased from 8.4 to 17 mg/l as $CaCO_3$ between stations ER02 and ER03. Copper and nickel, which may have leached from the filtering plant pipes, in addition to aluminum, mercury, and lead, exceeded their recommended criteria. Although the gradient was less steep and less pool habitat was available than at ER02, the habitat was excellent. The macroinvertebrate community was rich in intolerant organisms. A total of twenty one eastern brook trout, fifteen of which were YOY, were captured during the electroshocking. Fish were more abundant in this section (12/100m^2), however, abundance may be limited by low flow events and possibly metal-related toxicity.

AB01 - Anthony Pond Brook (outlet of Anthony Pond)

Anthony Pond Brook, a first order stream which runs parallel to the Egypt Reservoir drainage was also sampled on 4 August. The susceptibility of the stream to acidification was evident from the physicochemical data. Alkalinity was below 1.0 mg/l although the pH was higher (5.3) than at the reference station ER01. Exceedances of the EPA chronic criteria were documented for aluminum, copper, mercury, zinc, and lead. Habitat, however, was rated as excellent. The gradient at AB01 was somewhat steeper than at ER03 but less pronounced than the gradient at ER02. The macroinvertebrate community was considered non-impacted although the fish density seemed low (8 fish/100m^2) based on professional judgement in relationship to the available habitat. Once again, eastern brook trout was the only species collected or observed. Low-flow, acidic conditions, and/or metal-induced toxicity may be impacting the fish population at this site.

CB01 - Cady Brook - (tributary to Cleveland Reservoir)

Cady Brook, a small third order tributary with a drainage area of 7.5 km^2, was sampled as a regional reference station on 5 August. Stream flow (3.8 cfs) appeared to have subsided some from the previous day's heavy rains. Although hardness and alkalinity were still low, pH was near neutral (6.8). Zinc and lead were the only metals exceeding their recommended chronic criteria (Figure 2). Habitat was again rated as excellent overall, although there appeared to be a slight lack of defined pools and streamside cover. The macroinvertebrate community appeared to be evenly distributed and rich in intolerant organisms (refer to Figure 5). Three species of fish were collected. Species present, in order of abundance, included eastern brook trout, blacknose dace and one brown trout. Although only one brown trout was collected, it appeared to be a native fish, as it was much smaller (approximately 100 mm in length) than those normally stocked by the Massachusetts Division of Fisheries and Wildlife (MDFW). A total of fifty eight fish (not including YOY) were collected in this reach (39 fish/100m^2), and it was obvious that many YOY dace were passing through the nets.

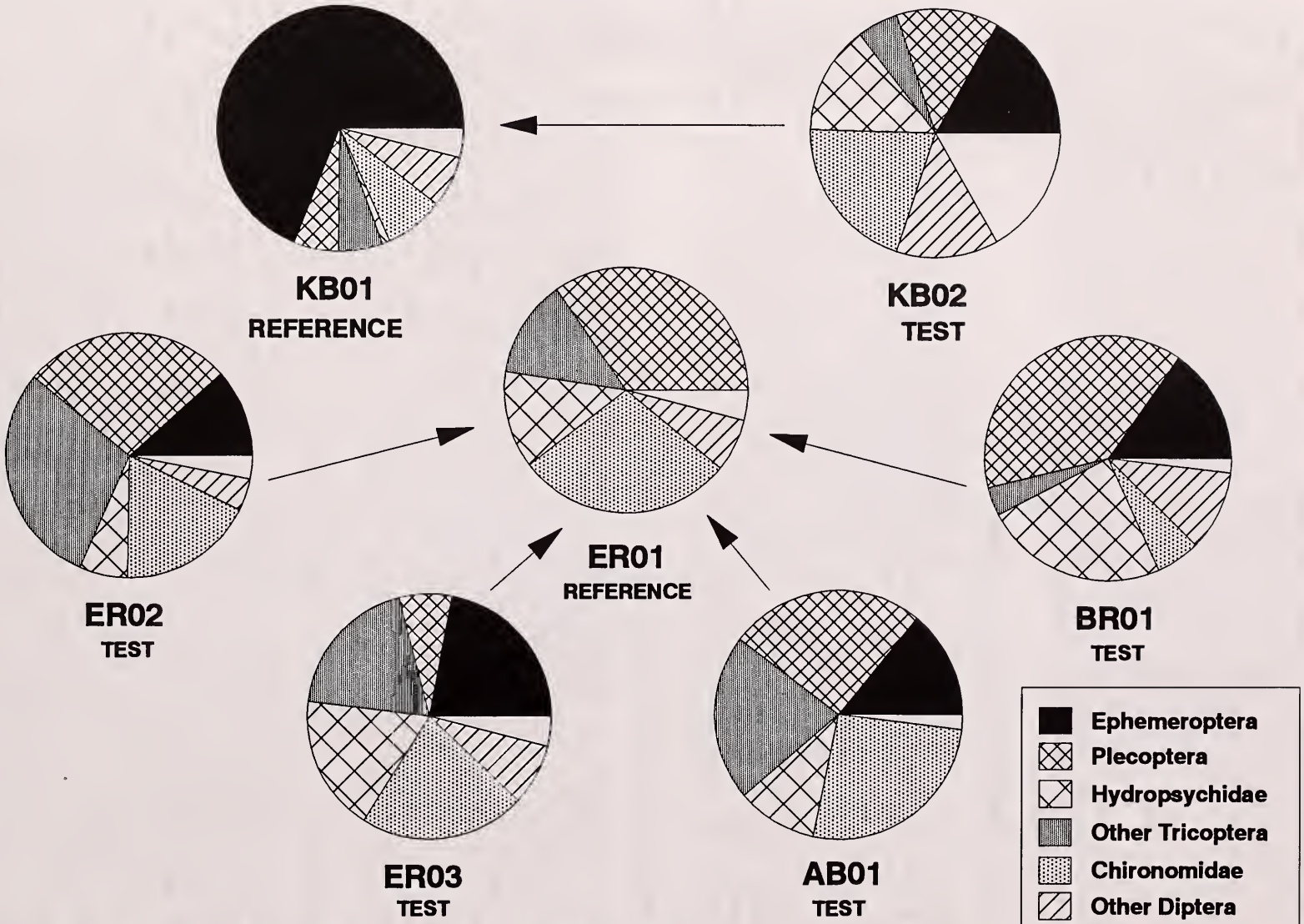

FIGURE 4. Percent composition of benthos in first order Housatonic River Tributaries

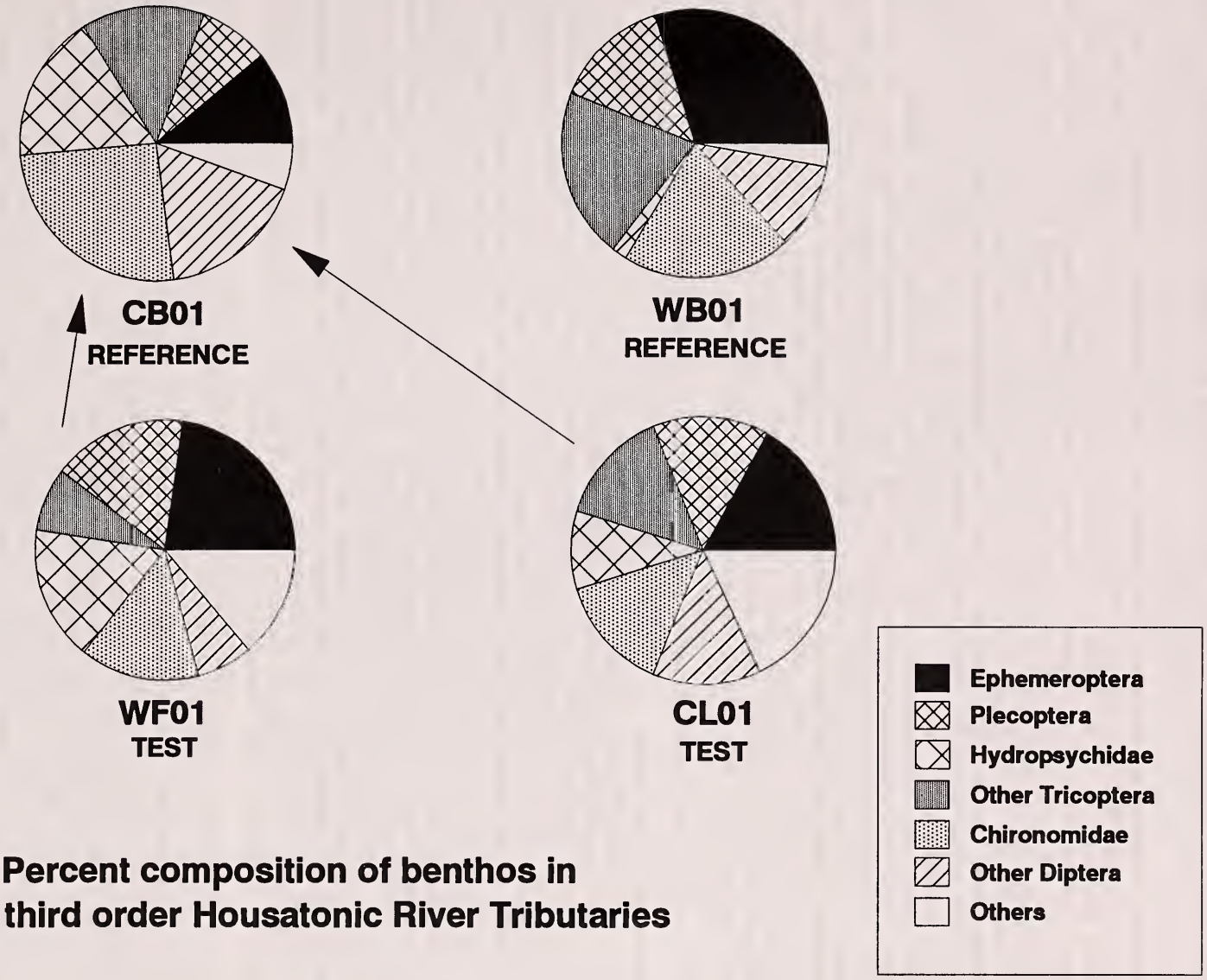

FIGURE 5. Percent composition of benthos in third order Housatonic River Tributaries

WB01 - Windsor Brook - (tributary to Windsor Reservoir, diverted to Cleveland Reservoir)

Windsor Brook, a large third order stream (drainage area = 24.6 km^2), is currently being diverted into Cleveland Reservoir. This regional reference site had a streamflow of 22.5 cfs on 5 August which appeared consistent with what was noted during the July reconnaissance survey. The stream appeared to be better buffered in comparison to the Egypt Brook and Anthony Pond Brook systems with an alkalinity of 27 mg/l as $CaCO_3$ and a pH of 7.5. Lead was the only metal found to exceed the EPA chronic criteria. The habitat was excellent, although the canopy was primarily open at the site, whereas most of the other sampling stations were shaded. The benthos were found to be diverse and well-balanced with the dominant family comprising only 21% of the sample. Electroshocking efficiency was rated poor (<50% pick-up) due to the width of the stream. As was noted earlier, two electroshocking units would have been more appropriate at this site. Eastern brook trout dominated the collection at this station. One longnose dace was collected, however, due to the poor electrofishing efficiency, other longnose dace and additional species may have been present in Windsor Brook. The number of fish (16) was very low; however, this number is only a percentage of those which were observed and not captured. Re-sampling of a couple of the larger pools where fish were observed but not captured during the first pass was not successful. For these reasons, fish density was not calculated.

WF01 - Wahconah Falls Brook - (outlet of Windsor Reservoir)

Wahconah Falls Brook, a medium sized third order stream (drainage area = 14.7 km^2) was sampled on 5 August. Streamflow was about half that of Windsor Brook, at 11.3 cfs. Although pH was slightly low (5.7), water quality was quite similar to that of Windsor Brook as the stream had an alkalinity and hardness of 28 and 34 mg/l as $CaCO_3$, respectively and lead was the only metal which exceeded its criterion. Benthic samples collected from this station appeared to indicate a well-balanced invertebrate community with the dominant taxon contributing only 17% and a taxa richness of 21 families. Stream conditions included slightly colored water, a totally enclosed canopy, and slick substrates which made electroshocking difficult; however, this station still produced the most diverse fish assemblage of all stations sampled. The Vermont IBI was employed to score this station, due to the fact that all of its conditions for use were met (See Table 11 and Appendix D). Wahconah Falls Brook scored 41 of a possible 45 and rated good/excellent. Fish density was also excellent at 19.7 fish/100m^2 (see metric 9, Vermont IBI). Increased productivity, as evidenced by the extensive coverage of the bottom by periphyton, most likely as a result of the proximity of the station to Windsor Reservoir, was probably responsible for the increased species richness and abundance at this station.

CL01 - Cleveland Brook - (outlet of Cleveland Reservoir)

The first order tributary from the outlet of Cleveland Reservoir, Cleveland Brook, was sampled on 5 August. The flow appeared to be similar to that which was noted during the July reconnaissance survey. Stream discharge measured 1.3 cfs. The water quality of Cleveland Brook was the most well buffered of all the stations in the Dalton/Hinsdale area. Aluminum, mercury, and lead were found to be in excess of their respective criteria (Figure 2), although hardness was considerably higher than the other stations sampled (72 mg/l as $CaCO_3$). As previously noted, total solids were the highest of any of the stations sampled. Deposition on the streambed was responsible for the slightly lower habitat score at this station. Deposition appeared to be a result of very steep banks on one side of the stream as well as road sand runoff on the downstream side of the bridge. The benthic macroinvertebrate community was well balanced with a richness of 17 families and the % contribution of the dominant family of only 15. Fish abundance was also excellent at 49.5 fish/100m^2. Eastern brook trout and brown trout (all age classes) dominated the fish population at this station. One longnose dace was also collected, and many YOY dace were observed.

It should also be mentioned here that Cleveland Reservoir receives the total flow of Windsor Brook through an aqueduct; however, this large volume of flow (approximately 22 cfs) was not evident in Cleveland Brook (approx. 1.3 cfs) at the time of sampling. Cleveland Brook contained flow more representative of a first order stream with a relatively small drainage area (3.3 km^2).

BR01 - Outlet of Belmont Reservoir

The outlet stream from Belmont Reservoir in Hinsdale, a small first order stream, was sampled on 3 August. The stream discharge of 0.085 cfs appeared to be indicative of the low-flow conditions at this site since there was no antecedant rainfall on 2 August. The drainage basin up-gradient of the sample reach was quite small (1.4 km^2), and the discharge rate was the lowest of all of the stations sampled (0.15 cfs/mi^2). The pH was near neutral at 6.9, while alkalinity and hardness were 17 and 28 mg/l as $CaCO_3$, respectively. Water quality criteria were exceeded for iron, zinc, and lead (Figure 2). Iron precipitate was observed at the outlet of the reservoir, completely covering the streambed for approximately 0.25 mi. Habitat at the sampling station location, however, was rated excellent. The benthos were dominated by the plecopteran family Leuctridae (32%). Fourteen families were identified in the sample. Similar to the Egypt/Anthony Brook systems, the fish community was comprised predominantly of eastern brook trout, with the addition of one slimy sculpin, and the density (8.3 $fish/100m^2$) was considered fair according to the Vermont IBI.

KB01 - Karner Brook - (upstream of water withdrawal)

The reference station on Karner Brook, a small first order stream with a drainage area equal to 4.9km^2, was sampled approximately 0.2 miles upstream of the water withdrawal dam on 6 August. Stream discharge was calculated as 0.726 cfs yielding a flow factor of 0.42 cfs/mi^2. The stream was well buffered in comparison to the other first order streams and had a pH of 7.3. Mercury was the only metal found to exceed its recommended water quality criterion, otherwise the water quality was excellent. Although logging activities were occuring in the area, the high gradient stream provided excellent habitat in the form of a series of pools, small waterfalls, and riffles. Surprisingly, the benthic community was found to be hyperdominated by two families of ephemeropterans, with Heptageniidae comprising 56% of the sample. This imbalance in the benthic community resulted in a RBPII total score for KB01 of 36 (see Table 9), whereas all of the other reference stations scored 42. Additional sampling of the benthic community is recommended at this site. The fish population consisted entirely of eastern brook trout (28 parr and adults, 24 young of the year). The fish density in this segment was excellent (27 $fish/100m^2$).

KB02 - Karner Brook - (downstream of water withdrawal)

Karner Brook was also sampled on 6 August downstream from the water withdrawal dam. Stream discharge was slightly less than at the upstream station (0.697 cfs, with a flow factor of 0.35 cfs/mi^2). The difference may be attributable to the water withdrawal, or may just be within the margin of error for the sampling method. Water quality was similar to that at KB01, although the alkalinity was approximately double. Lead, in addition to mercury, exceeded its water quality criterion. The available habitat at this station was also excellent, though the slope was not as steep as at KB01. The benthic community was much more evenly distributed than at KB01. Taxa richness increased to 21 families compared to 13 families at KB01, and the dominant family contributed only 20% of the sample. Overall, the RBP II score for station KB02 was 27. When compared to the total score for station KB01, KB02 was found to be 75% comparable and was considered to be borderline non-impacted. However, the reference station conditions at KB01 were less than ideal. Additional biomonitoring RBP III is recommended at this station. The fish population at KB02 was comprised of eastern brook trout (18 parr and adults, 1 YOY) and slimy sculpin (12 adults and >15 YOY). Additional YOY

slimy sculpin were observed, but not collected. Fish density at this station was slightly higher than that of the upstream segment (30 fish/100m^2). The absence of slimy sculpin in the upstream segment (KB01) is most likely due to the increased gradient, as well as the barrier to migration. There is no historical documentation of the presence of sculpin upstream of the water withdrawal dam.

LP01 - Long Pond Brook - (outlet of Long Pond)

Long Pond Brook was scheduled for sampling on 5 August; however, the streambed was dry downstream from the outlet structure. No sampling was performed.

GENERAL CONCLUSIONS AND RECOMMENDATIONS

1. The 1992 Housatonic River Tributary Biomonitoring Survey provided DWPC-TSS the opportunity to evaluate the biological condition of previously unassessed waters in terms of nonpoint source pollution impacts for the next 305(b) report.

2. The immediate benefit of the site visits was in gaining first-hand familiarity with the water withdrawal locations and their surroundings. Multiple site visits also proved invaluable by affording opportunities to see the respective water bodies under different flow conditions--particularly important since stream gaging data were not available.

3. Field reconnaissance efforts also revealed water withdrawals which resulted in dry streambeds. These situations are in clear violation of the Massachusetts Water Quality Standards which specifically protect aquatic life as well as other designated uses of the waterbodies in the Commonwealth. Permitting activities associated with these sites would not be effective in protecting the downstream uses of the waterbodies without the knowledge gained during the field reconnaissance effort.

4. Due to the precipitation which occured during the week of 3 August, the summertime base-flow conditions in the tributary streams were not realized. It is recommmended that for future water withdrawal studies, alternate sampling dates be scheduled to avoid wet-weather sampling conditions, if possible, including an antecedant dry period of three to five days.

5. The relationship between the biological integrity of the aquatic communities and the summertime base-flow conditions in the streams below the water withdrawals was not determined.

6. The concentrations of total metals in the Housatonic River tributaries, particularly mercury, zinc, and lead, are of concern and merit further investigation. Both aquatic life criteria and drinking water standards for lead were exceeded.

7. The use of RBP II and V monitoring provided baseline information (at current water withdrawal conditions) on the benthic and fish communities in the vicinity of the water withdrawal sites. Impacts from increases in water withdrawals at these sites can be determined through repeated monitoring efforts using the baseline data as a reference for comparison.

8. Two of the reference stations, ER01 and KB01, were found to be stressed; ER01 was acidified and no fish were observed or collected, and the benthos at KB01 was hyperdominated by a family of ephemeropterans. Thus, less than ideal conditions at the reference stations were encountered, although intolerant organisms were also present in these sampling reaches.

9. The benthic communities present in the streams sampled contained generally healthy and diverse assemblages, which were rich in intolerant organisms. While the goal of the fisheries portion of this survey (to employ an Index of Biotic

Integrity in order to document the effects of water withdrawals) was unachieved, fish density calculations and best professional judgement guided the assessments.

10. Cady Brook (CB01) and Windsor Brook (WB01) were sampled as reference stations. Both were third order streams; however, Windsor Brook's drainage basin and flow (9.52 mi^2, 22.5 cfs) were much greater than those of Cady Brook (2.9 mi^2, 3.8 cfs). Since the fish assemblage in Cady Brook did not contain enough stream species, the Vermont IBI could not be applied. Additional work on small third order streams in this region would have to be performed in order to judge whether this was due to an unknown impact, or indeed was indicative of a least-impacted stream with similar drainage area in this region. Due to the inefficiency of the electrofishing effort in Windsor Brook (WB01), it is impossible to draw conclusions regarding the fish community sampled.

SITE-BY-SITE RECOMMENDATIONS

Egypt and Anthony Brooks

The location of the Egypt Brook Reservoir appears to be acting as a buffer to low pH conditions that occur at ER01, and is probably enhancing the eastern brook trout populations present at ER02 and ER03. It appears that the brook trout populations at ER02 and AB01 are limited either by the episodic low flow conditions (leakage only), similar to those found during the July reconnaissance, and/or by metal-related toxicity. The same would probably be true at ER03; however, at this station (ER03), Egypt Reservoir Brook receives some overflow from Little Egypt Reservoir. A question arises as to why the Town of Dalton diverts flow from Anthony Brook and Egypt Reservoir in excess of what is needed and overflows the excess to the lower section of Egypt Reservoir Brook. It would probably be beneficial and enhance available habitat if any excess flow were allowed to continue in its natural drainage channel.

Windsor Reservoir and Wahconah Falls Brook

The present withdrawal from Windsor Reservoir does not appear to be impacting the benthic or fish communities in Wahconah Falls Brook. The fish community was considered excellent according to the Vermont IBI. The data generated could be used for future reference, should an increased withdrawal be proposed or granted at this site. The site cannot be used as a reference site due to its location just downstream of a major impoundment.

Cleveland Reservoir and Cleveland Brook

The aqueduct on Windsor Brook, which supplies water to Cleveland Reservoir, has resulted in the elimination of approximately 0.25 miles of the brook. At the time of the field survey at WB01, the entire flow of Windsor Brook (22.5 cfs) was shunted through the aqueduct. It is recommended that a minimum streamflow requirement be imposed as part of this water withdrawal permit.

The water withdrawal from Cleveland Reservoir does not appear to be impacting either the benthic or fish communities in Cleveland Brook (CL01); however, one must keep in mind that Cleveland Reservoir was receiving 22.5 cfs from the Windsor Brook diversion, and this was by no means evident from the flow present in Cleveland Brook (1.2 cfs). Unfortunately, it was not documented as to whether Cleveland Reservoir was flowing over the dam or if the flow was primarily leakage from the Reservoir. Regardless, it does not appear that recent conditions in Cleveland Brook have stressed the biota.

Belmont Reservoir and outlet stream

Belmont Reservoir Brook (BR01) is a small first order headwater stream. Its fish community was indicative of such (dominated by eastern brook trout). The only flow evident below the reservoir was from a PVC pipe which appeared to be an

underdrain to the dam. Given this minimum streamflow condition, and the fact that the drainage area is only 0.55 mi^2, the results of the biological assessment appear to indicate that the present water withdrawal does not adversely impact the biota in Belmont Reservoir Brook.

Karner Brook

An increased water withdrawal from Karner Brook (KB01, KB02) appears to have a substantial risk of impacting the aquatic communities. The RBP II assessment indicated a potential (non-impacted/borderline-impacted) problem. Although the present water withdrawal does not appear to be negatively impacting the fish community, there is no impoundment on the stream to lessen or buffer the effects of a withdrawal during low flow periods, whether they occur in the summer or not. Any increased withdrawal will come directly from this small first-order stream, directly impacting the low flow conditions at KB02. It is recommended that RBP III (species level identification) and RBP V monitoring be conducted on a yearly basis, in conjunction with physicochemical monitoring, to detect and prevent adverse impacts to this stream. Additionally, water quantity information, including a flow duration curve, should be developed for this stream to better assess the relationship between biological integrity and streamflow.

Long Pond and Long Pond Brook

The Long Pond withdrawal has resulted in the elimination of a portion of Long Pond Brook (approximately 0.25 miles) under current withdrawal conditions. Although this withdrawal exacerbates the naturally occuring low-flow condition in the reservoir, impacts to any established wetlands would occur if a minimum streamflow requirement was imposed. It is therefore recommended that the Wetlands Division of the Western Regional Office be given the opportunity to review this permit. A balance between minimum streamflow requirements and reservoir level, which would afford the most protection to both Long Pond Brook and any contiguous wetlands around Long Pond, would then be required in the water withdrawal permit.

REFERENCES

CMR. 31 January 1992. Massachusetts Water Resources Management Program. 310 Code of Massachusetts Regulations 36.00. Department of Environmental Protection, Boston, MA. pp. 799 - 808.12.

Fassett, N.C. 1972. A manual of aquatic plants (with revision appendix by E.C. Odgen). University of Wisconsin Press, Madison, WI. IX + 405 p.

Fernald, M.L. 1970. Gray's manual of botany: a handbook of the flowering plants and ferns of the central and northeastern United States and adjacent Canada. D. Van Nostrand Company, New York. LXIV + 1632 p.

Greenberg, A.E., L.S. Clesceri, and A.D. Eaton (editors). 1992. Standard methods for the examination of water and wastewater. American Public Health Association, American Water Works Association, and Water Environment Federation. Washington, DC. XXXI + 949 p.

Karr, J.R., K.D. Fausch, P.L. Angermeier, P.R. Yant, I.J. Schlosser. 1986. Assessing biological integrity in running waters a method and its rationale. Special Publication 5. Illinois Natural History Survey. Champaign, IL. 28 p.

Langdon, R.W. 1992. Personal communication. Vermont Department of Environmental Conservation, Waterbury, Vt.

Lind, O.T. 1974. Handbook of Common Methods in Limnology. The C.V. Mosby Commpany. Saint Louis, MO. 154 p.

MA DEP. 1990. Massachusetts surface water quality standards. Massachusetts Department of Environmental Protection , Division of Water Pollution Control, Technical Services Branch. Westborough, MA. 106 p.

Omernick, J.M. 1987. Ecoregions of the northeast states (map). Environmental Research Laboratory, U.S. Environmental Protection Agency, Corvallis, OR. EPA/600/D-87/313.

Plafkin, J.L., M.T. Barbour, K.D. Porter, S.K. Gross, and R.M. Hughes. 1989. Rapid bioassessment protocols for use in streams and rivers: benthic macroinvertebrates and fish. U.S. Environmental Protection Agency, Assessment and Watershed Division. Washington, DC. EPA/600/4-85/013. 216 p.

Tiner, R.W., Jr. 1988. Field guide to nontidal wetland identification. Maryland Department of Natural Resources, Annalpolis, MD and U.S. Fish and Wildlife Service, Newton Corner, MA. XV + 283 p. + plates.

TSB. 1989. Basin planning section standard operating procedures. Massachusetts Department of Environmental Protection, Division of Water Pollution Control, Technical Services Branch. Westborough, MA 51 p.

APPENDIX A

Summary of four-day average water quality criteria for selected metals

PARAMETER	CRITERION* (reported in mg/l)	REFERENCE
Aluminum	0.087 (between pH 6.5 and 9.0)	EPA. 1988. Ambient water quality criteria for Aluminum - 1988. U.S. Environmental Protection Agency. Washington, DC. EPA 440/5-86-008. 47 p.
Iron	1.0	EPA. 1976. Quality criteria for water. U.S. Environmental Protection Agency. Washington, DC. 256 p.
Mercury	0.000012	EPA. 1985a. Ambient water quality criteria for mercury - 1984. U.S. Environmental Protection Agency. Washington, DC. EPA 440/5-84-026. 136 p.
Copper	e(0.8545(lnH)-1.465 H = 25 (0.0036)	EPA. 1985b. Ambient water quality criteria for copper - 1984. U.S. Environmental Protection Agency. Washington, DC. EPA 440/5-84-031. 142 p.
Zinc	e(0.8473(lnH)+0.7614 H = 25 (0.033) H = 28 (0.036)	EPA. 1987. Ambient water quality criteria for zinc - 1987. U.S. Environmental Protection Agency. Washington, DC. EPA 440/5-87-003. 158 p.
Lead	e(1.273(lnH)-4.705 H = 25 (0.00054) H = 28 (0.00063) H = 34 (0.00081) H = 35 (0.00084) H = 48 (0.00125) H = 72 (0.00209)	EPA. 1985c. Ambient water quality criteria for lead - 1984. U.S. Environmental Protection Agency. Washington, DC. EPA 440/5-84-027. 81 p.
Nickel	e(0.8460(lnH)+1.1645 H = 25 (0.049)	EPA. 1986. Ambient water quality criteria for nickel - 1985. U.S. Environmental Protection Agency. Washington, DC. EPA 440/5-86-004. 93 p.

* Where appropriate, formulas are presented when the criterion is hardness dependent. In cases where the instream hardness levels were below 25 mg/l as $CaCO_3$, a hardness of 25 mg/l as $CaCO_3$ was used to calculate the criterion as recommended in the guidance published in the Federal Register (Vol. 57; No. 246) on December 22, 1992. The criteria have been calculated according to their respective formulas, using the hardness values (H) obtained during the survey, and are noted in parenthesis.

APPENDIX B
1992 HOUSATONIC RIVER TRIBUTARY BIOMONITORING SURVEY
Predominant Riparian and Aquatic Vegetation

APPENDIX B (continued)

ER01 (Inlet Egypt Reservoir)

Lycopodium sp. "a Clubmoss"

Dryopteris spinulosa Spinulose Woodfern

Marsilea quadrifolia Pepperwort

Tsuga canadensis Hemlock

Picea rubens Red Spruce

Medeola virginiana Indian Cucumber Root

Trillium undulatum Painted Trillium

Betula lutea Yellow Birch

Coptis groenlandica Goldthread

Acer pensylvanicum Striped Maple

Acer saccharum Sugar Maple

Acer rubrum Red Maple

Viola sp. "a Violet"

Viburnum alnifolium Hobblebush

Aster sp. "a Aster"

ER02 (Outlet Egypt Reservoir)

Lycopodium sp. "a Clubmoss"

Dryopteris spinulosa Spinulose Woodfern

Marsilea quadrifolia pepperwort

Tsuga canadensis Hemlock

Cyperus sp. "a Sedge"

Smilacina racemosa False Soloman's Seal

Betula lutea Yellow Birch

Fagus grandifolia Beech

Hamamelis virginiana Witch-Hazel

Rhus allegheniensis Common Blackberry

Acer pensylvanicum Striped Maple

Acer saccharum Sugar Maple

Acer rubrum Red Maple

Impatiens capensis Spotted Touch-me-not

Mitchella repens Partridgeberry

Lonicera sp. "a Honeysuckle"

Viburnum acerifolium Maple-Leaved Viburnum

Aster sp. "a Aster"

Xanthium sp. "a Clotbur"

ER03 (Outlet Egypt Reservoir)

Lycopodium tristachyum Ground-Pine

Lycopodium annotinum Stiff Clubmoss

Onoclea sensibilis Sensitive Fern

Dryopteris sp. "a Wood Fern"

Polystichum acrostichoides Christmas Fern

Tsuga canadensis Hemlock

Arisaema triphyllum Jack-in-the-Pulpit

Smilacina racemosa False Soloman's Seal

Medeola virginiana Indian Cucumber Root

Trillium undulatum Painted Trillium

Ostrya virginiana American Hop-Hornbeam

Betula lutea Yellow-Birch

Betula nigra Black Birch

Betula papyrifera White Birch

Fagus grandifolia Beech

Hamamelis virginiana Witch Hazel

Prunus serotina Black Cherry

Acer pensylvanicum Striped Maple

Acer saccharum Sugar Maple

Aralia nudicaulis Wild Sarsparilla

Monotropa uniflora Indian Pipe

Trientalis borealis Star-Flower

Fraxinus americana White Ash

Mitchella repens Partridgeberry

Aster divaricatus White Wood Aster

AB01 (Anthony Brook)

Dryopteris sp. "a Wood Fern"

Marsilea quadrifolia Pepperwort

Tsuga canadensis Hemlock

Clintonia borealis Yellow Clintonia

Betula lutea Yellow Birch

Fagus gradifolia Beech

Coptis groenlandica Goldthread

Acer pensylvanicum Striped Maple

Acer saccharum Sugar Maple

Acer rubrum Red Maple

Fraxinus americana White Ash

Viburnum alnifolium Hobblebush

Viburnum acerifolium Maple-Leaved Viburnum

CB01 (Cady Brook)

Onoclea sensibilis Sensitive Fern

Dryopteris thelypteris Marsh Fern

Polystichum acrostichoides Christmas Fern

Tsuga canadensis Hemlock

Picea rubens Red Spruce

Populus tremuloides Quaking Aspen

Ostrya virginiana American Hop-Hornbeam

Betula lutea Yellow Birch

Betula nigra Black Birch

Fagus grandifolia Beech

Thalictrum polygamum Meadow-Rue

Acer pensylvanicum Striped Maple

Acer rubrum Red Maple

Fraxinus americana White Ash

Viburnum alnifolium Hobblebush

Aster divaricatus White Wood Aster

Xanthium sp. "a Clotbur"

WB01 (Windsor Brook)

Equisetum palustre Marsh Horsetail

Onoclea sensibilis Sensitive Fern

Dryopteris thelypteris Marsh Fern

Tsuga canadensis Hemlock

Hystrix patula Bottle-Brush Grass

Carex stricta Tussock Sedge

Populus tremuloides Quaking Aspen

Betula lutea Yellow Birch

Alnus rugosa Speckled Alder

Fagus grandifolia Beech

Acer saccharum Sugar Maple

Acer rubrum Red Maple

Lysimachia terrestris Yellow Loosestrife

Asclepias incarnata Swamp Milkweed

Eupatorium maculatum Joe-Pye-Weed

Xanthium sp. "a Clotbur"

WF01 (Wahconah Falls Brook)

Equisetum palustre Marsh Horsetail

Osmunda regalis Royal Fern

Onoclea sensibilis Sensitive Fern

Thelypteris palustris Marsh Fern

Polysticum acrostichoides Christmas Fern

Tsuga canadensis Hemlock

Ostrya virginiana American Hop-Hornbeam

Hamamelis virginiana Witch Hazel

Acer saccharum Sugar Maple

Viola sp. "a Violet"

Betula lutea Yellow Birch

Betula papyrifera White Birch

Prunella vulgaris Selfheal

Mentha piperita peppermint

Aster divaricatus White Wood Aster

Aster spp. "Asters"

Xanthium sp. "a Clotbur"

APPENDIX B (continued)

CL01 (Cleveland Brook)

Onoclea sensibilis Sensitive Fern

Thelypteris palustris Marsh Fern

Tsuga canadensis Hemlock

Ostrya virginiana American Hop-Hornbeam

Acer pensylvanicum Striped Maple

Impatiens pallida Pale Touch-Me-Not

Impatiens capensis Spotted Touch-Me-Not

Viburnum alnifolium Hobblebush

BR01 (Outlet Belmont Reservoir)

Osmunda claytoniana Interrupted Fern

Onoclea sensibilis Sensitive Fern

Dryopteris thelypteris Marsh Fern

Tsuga canadensis Hemlock

Carex sp. "a Sedge"

Arisaema triphyllum Jack-in-the-Pulpit

Smilacina racemosa False Soloman's Seal

Trillium undulatum Painted Trillium

Betula lutea Yellow Birch

Fagus grandifolia Beech

Rubus idaeus Red Raspberry

Acer pensylvanicum Striped Maple

Acer saccarum Sugar Maple

Impatiens capensis Spotted Touch-Me-Not

Aralia nudicaulis Wild Sarsparilla

Trientalis borealis Star-Flower

Fraxinus americana White Ash

Aster divaricatus White Wood Aster

KB01 (Karner Brook Upstream)

Onoclea sensibilis Sensitive Fern

Dryopteris sp. "a Wood Fern"

Tsuga canadensis Hemlock

Arisaema triphyllum Jack-in-the-Pulpit

Populus tremuloides Quaking Aspen

Betula lutea Yellow Birch

Betula nigra Black Birch

Berberis sp. Barberry

Fraxinus americana White Ash

Lonicera sp. "a Honeysuckle"

Aster divaricatus White Wood Aster

KB02 (Karner Brook Downstream)

Dryopteris sp. "a Wood Fern"

Polystichum acrostichoides Christmas Fern

Tsuga canadensis Hemlock

Betula lutea Yellow Birch

Betula nigra Black Birch

Hamamelis virginiana Witch Hazel

Geum rivale Purple Avens

Acer pensylvanicum Striped Maple

Acer saccharum Sugar Maple

Impatiens capensis Spotted Touch-Me-Not

Fraxinus americana White Ash

Viburnum alnifolium Hobblebush

Aster divaricatus White Wood Aster

Xanthium sp. "a Clotbur"

APPENDIX C
1992 HOUSATONIC RIVER TRIBUTARY BIOMONITORING SURVEY
MACROINVERTEBRATE SAMPLING DATA, 3-6 AUGUST 1992

	STATIONS										
TAXA	ER01	ER02	ER03	AB01	CB01	WB01	WF01	CL01	BR01	KB01	KB02
Oligochaeta Enchytraeidae											1
Lumbriculidae											1
Naididae						1					1
Tubificidae		1									
Hydracarina	2	1		1			2	1	1		
Insecta Ephemeroptera Baetidae		1	2		7	2	1	9	2		2
Ephemerellidae		5	6	5	2	14		1		15	
Heptageniidae			5	4	1	16	17	8	9	56	11
Leptophlebiidae		2	2				4		4		6
Odonata Aeshnidae		1									
Cordulegastridae			1								
Gomphidae		2	6	6	2		1		1		
Plecoptera Capniidae											2
Chloroperlidae			2	2	2		7	5	5	2	2
Leuctridae	12	23	1	20	2	1	5	3	34		
Nemouridae	23			2					1		
Peltoperlidae			3	3				5			1
Perlidae		3			3	14	2	2			1
Perlodidae			1		2					2	9

APPENDIX C (continued)

TAXA	STATIONS										
	ER01	ER02	ER03	AB01	CB01	WB01	WF01	CL01	BR01	KB01	KB02
Pteronarcyidae							3			2	
Megaloptera Corydalidae							4				
Sialidae	2			1			1	1			
Trichoptera Brachycentridae					9						
Glossosomatidae			4		1	8				2	1
Hydropsychidae	13	6	18	11	19	2	17	10	25	1	16
Hydroptilidae							1				
Lepidostomatidae	4	1	3	2		1					4
Limnephilidae		2	1	3		1	6				
Molannidae				4							
Odontoceridae	1	20	3								
Philopotamidae	1	1	8	2	3	1		6	1	2	1
Phryganeidae	1					1					
Polycentropodidae		4				7	1		3		
Rhyacophilidae	6			12	3	3		9		2	
Coleoptera Dytiscidae		1									
Elmidae (Larvae) (Adults)			3		4 2	1	2	4 12	1	4	1 13
Psephenidae						1	4	1			
Diptera Athericidae										1	1

APPENDIX C (continued)

TAXA	STATIONS										
	ER01	ER02	ER03	AB01	CB01	WB01	WF01	CL01	BR01	KB01	KB02
Blephariceridae						1					
Ceratopogonidae					4	2	3	3			
Chironomidae (Red)	1	1				1					
(Other)	28	16	22	28	28	21	15	15	6	8	23
Empididae		1	1								
Simuliidae	6				2						
Tipulidae	1	3	7		13	8	4	11	11	6	14
Gastropoda											
Lymnaeidae											1
Physidae							1				
Planorbidae			1								1
Total	101	95	100	106	109	107	101	106	105	103	113

APPENDIX D

THE VERMONT IBI

			Scoring Criteria		
			5	3	1
Species Richness and Composition					
1.	Total number of fish species		(Follows maximum species)		
2.	Number and identity of intolerant species	[Site Elevation >125m]	<1	1	0
		[Site Elevation <125m]	1	0	-
3.	Number and identity of benthic insectivores		>2	1-2	0
4.	Proportion of individuals as white suckers		<10%	10-25%	>25%
Trophic Composition					
5.	Proportion of individuals as generalist feeders	[Site Elevation >210m]	<20%	20-45%	>45%
		[Site Elevation <210m]	<30%	30-60%	>60%
6.	Proportion of individuals as insectivores	[Site Elevation >210m]	>65%	30-65%	<30%
		[Site Elevation <210m]	>55%	20-55%	<20%
7.	Proportion of individuals as top carnivores:	Cold Water	>10%	3-10%	<3%
		Warm Water	>5%	1-5%	<1%
Fish Abundance and Condition					
8.	Proportion of individuals with disease, tumors, fin damage and other anomalies		<2%	2-5%	>5%
			5	1	*
9.	Abundance in Sample (one pass - #100m^2)	[Site Elevation <210m]	>20	10-20	<10
		[Site Elevation >210m]			
		[Alk. >9mg/l]	>10	7-10	<7
		[Alk. <9mg/l]	>6	3-6	<3

*Site fails to meet Class B/C Standards

Metric Scores	
Excellent	43-45
Good	37-39
Fair	31-33
Poor*	< 27-29

Conditions for Use

1. For wadeable streams only.
2. At least four nonsalmonid species including one generalist feeder.
3. Only individuals more than 25mm TL.
4. Only resident stream species.
5. Count all trout species as one species only.
6. Only species with more than one individual captured are entered in metrics 2 & 3.

010-0832.92